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METHODS OF TRAVEL TIME PLANNING FOR DELIVERY VANS IN AGGLOMERATIONS

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1. Introduction

Traffic management in agglomerations can be effective by support of ITS (Intelligent Transportation Systems). Introduction of these systems is usually long and expensive process. ITS systems are designed to control smoothness of traffic in a city or entire agglomeration [1]. Duration of travel and delivery time is a key factor for logistics companies. It has major impact on supply chain and quality of service [3].

Delivery time or simple transit through agglomeration is usually complicated in peak hours. In some cases the drivers can be informed about traffic jam or congestion level by digital displays at the side of the road or transmitted by radio messages. An alternative route can be displayed or average delay time. These solutions are effective in cities with good communication arteries like motorways or express ways or ring roads. Unfortunately there are no such complex solutions in Poland and in majority of cities in European Union are rare.

2. Determination of travel time basing on digital maps software

Within last years satellite navigation systems became widely used in automobile vehicles. There are few analytical methods for calculating communication speed of vehicles [2, 4]. There were several on-line fleet management systems applied especially in logistics companies. The GPS based modules are implemented with digital maps software that can help in travel in unknown area and also in big cities or agglomerations with high density of roads infrastructure [5]. Usually the software has the option to determine route of the shortest distance or time. In majority of applications these data are generated in simplified method taking into account only part of parameters of selected route. The key factor determining reaching the destination point is communication speed. The precision of estimation of travel time determined by digital software is low. The difference of predicted travel time by digital maps software producers is relatively high. Example of a route in Silesian Agglomeration is presented in the fig. 1.

The travel time determined for this route for two types of the route (shortest and the fastest) differs from 17 to 29 minutes (fig.2). It was determined in various navigation software.

The method of estimation vehicle travel time applied for delivery vans in logistics companies is inaccurate and it is difficult to predict precisely how much time the drivers need to supply goods for different destination points in agglomeration.

3. Determination of travel time in dynamically changing traffic conditions

The first method described in the paper is based on static data for selected sections of the route. Other factors influencing travel time are not included. One of the most important factors is congestion in the city. It has important influence on the travel time and it should be included in planning routes for delivery vans [2, 4]. In the past few years new systems were introduced in some countries. In these systems the congestion level is included when displayed on the website. The principle of operation is based on sending traffic information by users by GPRS based systems. The information is sent to server and it is displayed online on the distributors' website (fig.3) [9]. This kind of system is more accurate but it requires many users to be involved in this system to send precise data about traffic conditions. In many cases it operates as beta version of digital maps distributors. In the future it should have major importance in planning of delivery vans routes.

Fig. 1. Example of a route in Silesian agglomeration

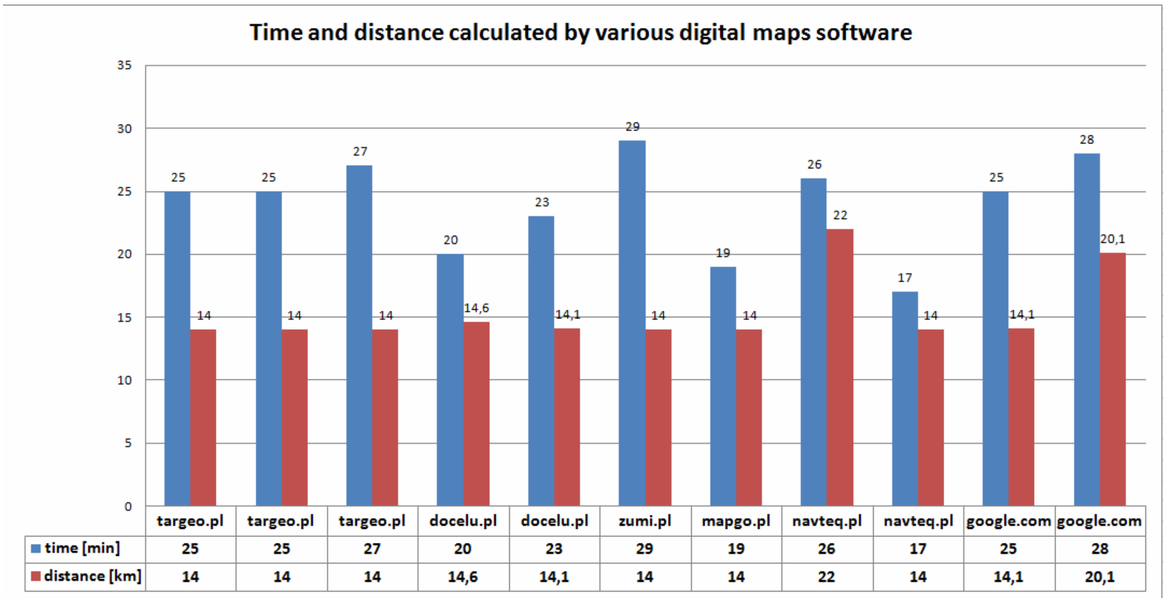

Fig. 2. Differences of travel time of software distributors between similar routes in Silesian Agglomeration

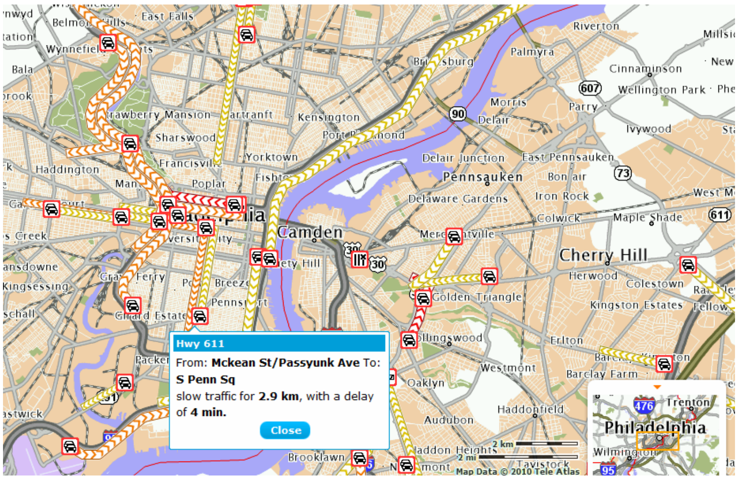

Fig. 3. Example of advanced digital maps systems including traffic information

4. Tests of travel time in congestion in the city of Katowice

In navigation systems applied in vehicles it can be precisely displayed time of reaching destination point of selected route (it is usually given length and travel time). In practice real time is usually different from theoretical it was discussed in the previous points.

It has been made test to verify influence of congestion on theoretical travel time given by digital map software.

For the tests it has been selected the routes in a city of Silesian Agglomeration – Katowice. Tests were made in congestion conditions. Selected routes included passing the city centre. The direction was from North towards South passing the city Centre of Katowice. There were 9 different routes connecting the same start and end point.

Fig. 4. Start and end point (1, 2) for testing routes

There are many combinations of routes between these two points. The length of the trails can be variable depending on selection of Eastern, central or Western direction. Trip duration proposed by navigation system for the shortest or the fastest way can be different in real.

The results are presented in the plot (fig. 5).

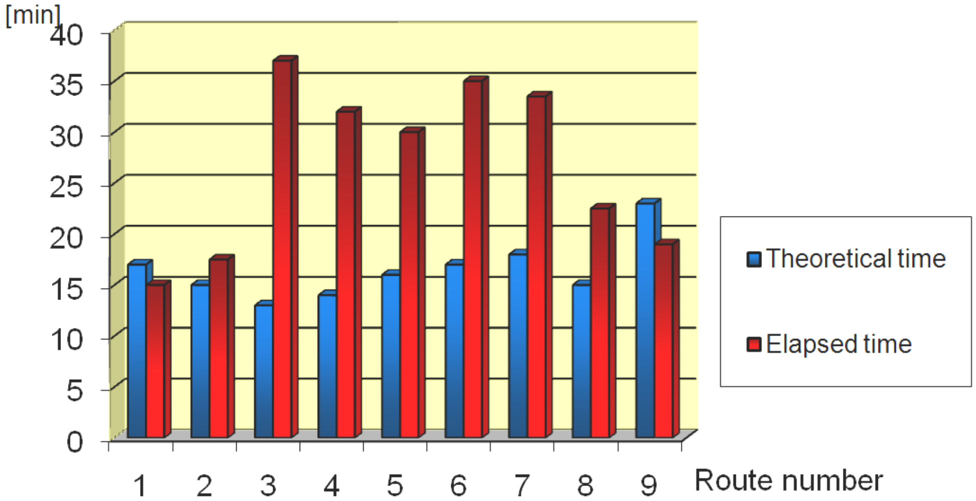

Fig. 5. Results of theoretical and elapsed time for different routes connecting the same points

In the table 1 there are set duration of travel in real congestion conditions with theoretical travel time (calculated for the trips in Google Maps) to compare results. In other navigation systems available in Poland it is comparable.

Table 1

Comparison of theoretical with recorded travel time in tests

Route No	Route length **[km]**	Theoretical travel time calculated in digital map software **[min]**	Recorded travel time for selected route **[min]**	Average communication speed **[km/h]**
1	6,5	17	15	26,0
2	6,6	15	17,5	22,6
3	6,5	13	37	10,5
4	6,4	14	32	12,0
5	8,9	16	30	17,8
6	8,0	17	35	13,7
7	8,5	18	33,5	15,2
8	9,3	15	22,5	24,8
9	8,9	23	19	28,1

In the preparation of the route plan it was considered shortest and fastest trails proposed by navigation software and also routes including two-lane way, main road and local road.

Two of the test routes have been driven in time slightly shorter than calculated by digital map software (trail 1 and 9). It was connected with very low congestion and driving on two-lane way where the main stream of vehicles was moving above speed limit 50km/h. For majority of routes – travel time was much longer exceeding theoretical time about 100% or over this value (trail 3 - 6).

The results of the test reflected congestion level in the city for that time and other factors influencing and lengthening time of travel (tram, pedestrians crossing etc.). Basing on this research it can be found the travel time given in vehicle navigation systems did not include congestion level which had high impact on duration travel.

However there were some systems introduced [8, 9] that include traffic data but the precision is not satisfactory especially in the centers of highly congested cities.

5. Application of artificial intelligence systems for determination of routes

Planning delivery time for delivery vans incurs some errors. It is considered with changing in time traffic levels. Available systems do not take all possible solutions in planning of the routes.

Possible errors in travel time estimation have been described in points 2 and 3 of this paper. Therefore it is proposed to use artificial intelligence systems to solve such problems. Artificial immune systems use selected mechanisms of natural immune systems, it was described in [5, 7]. The scheduling road for supplier van, which serves customers waiting in fixed places and fixed time, can be formulated as a problem of minimising length of the road, of minimising the time of the drive and of maximising the number of the operated customers (fig. 6).

There were some cases calculated considering delivery of goods by van in a city of Silesian agglomeration. The vans were delivering goods for different points in the city of Tychy in Silesian Agglomeration. It has been used artificial immune systems and nearest neighbor method to calculate the shortest and fastest route for delivery of the van [6]. The results are presented in the table 2. The optimal route is presented in the fig. 6.

Table 2

Results of optimization

	Nearest neighbour method	Artificial immune system Shortest route	Artificial immune system Fastest route
Route Length	**55,95 km**	**54,29 km**	**57,74 km**
Elapsed Time	**6 h 54 min**	**6 h 51 min**	**5 h 32 min**

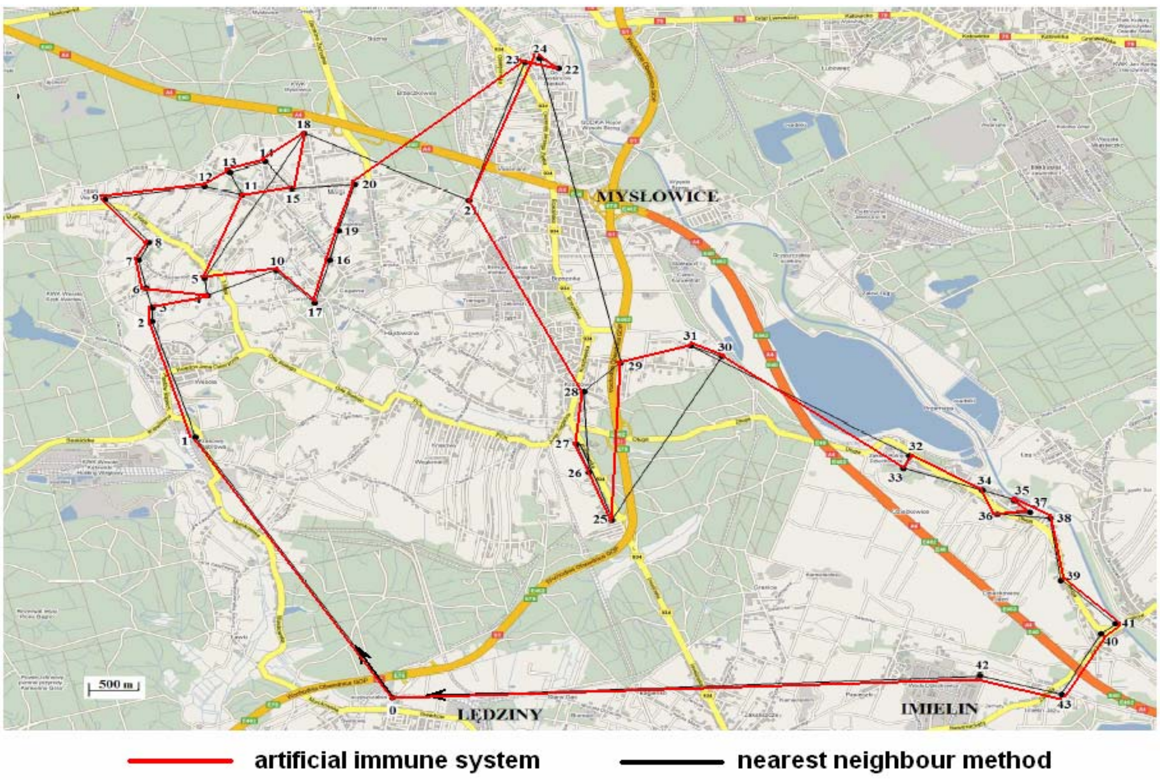

Fig. 6. Route of delivery van optimized by artificial immune system

6. Conclusions

Congestion level in agglomerations has high influence on communication speed and increasing travel time. Therefore it is difficult to plan precisely delivery of goods in highly populated agglomerations. There are trials to solve the problem with implementation of GPS/GPRS based systems that can send current traveling time on individual sections of a trail on server and other users could be informed about travel conditions immediately. These systems are based on data collected from traffic users. It is necessary to have operating GPS/GPRS module in the vehicle or some models of mobile phones. Server side software can collect data and send current traffic info to requesting user. There are changeable parameters of the traffic included and it is possible to propose alternative route with lower congestion level.

The results presented in the paper indicate the artificial intelligence systems can be used for solving problems in delivery planning for supplying vehicles operating in highly populated cities.

Further work should be focused on including changeable traffic conditions in calculations.

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